Housing, household transmission and ethnicity: For SAGE meeting 26th November 2020

Consensus statement

Date: 24th November 2020

Context

1. Households[1] are an important contributor to the transmission of Covid-19 *[high confidence]*, although how infection is transmitted into households and within households is unclear.

2. This paper analyses new data from five population studies (ONS, REACT-Imperial, Biobank, QResearch and OpenSAFELY) and considers the extent to which household composition (defined as the number of people living in the same household and their ages) might explain how some minority ethnic groups in the UK have been disproportionally affected by Covid-19. The data were collected from March to August 2020. In addition, the paper draws on ethnographic research carried out since April 2020 (Bear et al., 2020) and on sociological and health literature.

3. This paper builds on – and should be read in conjunction with – the following SAGE papers: *Covid-19 Housing Impacts (SPI-B and EMG, 2020)*, *Evidence Review for MHCLG Housing Impacts (SPI-B, 2020a)* and *Evidence Review for MHCLG Housing Impacts (EMG, 2020)*. Forthcoming/accompanying SAGE advice on minimising household transmission will be/is also relevant.

4. This paper is presented alongside *Approaches to Mitigate Risks Associated with Social Interaction within the Home with People from Outside the Household (EMG and SPI-B, 2020).*

Findings

5. Five recent national studies have examined the relationship between Covid-19, ethnicity, and household characteristics. The studies use different types of population datasets, different definitions of household composition and different methods (see Table 1 in main paper). Their results, though, are largely consistent (Table 2).

6. The studies all find that household composition (i.e. number of people in the household and their ages) are key factors in terms of risk of Covid-19 infection and mortality, even when controlling for deprivation and other factors. There is increased risk of infection and mortality for those living in larger occupancy households. **There is a correlation between large /multigenerational households and increased risk of infection and or mortality across all five studies, even when controlling for deprivation and other factors.** *[high confidence]*

7. The OpenSAFELY, QResearch and ONS results indicate that household composition explains a proportion of the additional risk of Covid-19 infection and mortality in South Asian ethnic groups, but not in other ethnic groups. *[medium confidence]*

8. The study by ONS found an increased risk of Covid-19 mortality for those living in multigenerational households, defined as households with at least one person aged 65 or over and one person 20 years

[1] A household is defined as 'one person living alone, or a group of people (not necessarily related) living at the same address who share cooking facilities and share a living room, sitting room or dining area. A household can consist of a single family, more than one family or no families in the case of a group of unrelated people' (Office for National Statistics, 2019).

younger. Part of the excess risk of mortality for South Asian women compared to White women could be explained by living in a multigenerational household, but this did not explain the excess mortality experienced by men in this ethnic group or in women of other ethnic minority groups [vi]. *[medium confidence]*

9. **Overall, these studies support conclusions from an earlier SAGE-endorsed paper (SPI-B and EMG, 2020) which suggested a link between household composition and the risks of transmission and mortality from Covid-19 – but which also found that household composition can only partly account for severe Covid-19 outcomes across minority ethnic groups.** *[medium confidence]*

10. The pathways explaining the findings from the national studies are not well understood, but are likely to be multiple and interrelated *[high confidence]*. For example, poorer housing conditions, linked to long-term economic constraints, including differential access to social security, and job roles, could be associated with increased transmission and poorer health outcomes and/or increased co-residence in order to pool limited resources.

11. Other factors, besides housing conditions and care arrangements, are known to be significant in relation to risk of household transmission, including: occupations of household members; familial and social connections outside the house; sharing of common spaces and facilities; the presence of comorbidities and vulnerable individuals; domestic responsibilities besides care; and intimate social relationships*. [medium confidence]*

12. Overall, it is difficult to draw firm conclusions about the mechanisms by which household composition contributes to higher infection and mortality risk among minority ethnic groups. There are too many factors that would need to be considered concurrently, though it is possible that future work, both quantitative and qualitative research examining the occupations of household members, differences in access to space and quality of housing, and intra-and inter-household patterns of connections, could provide further insights into whether and how household effects differ across different ethnic groups. In the absence of certainty of evidence, the recommendations below seek to highlight ways in which household-related risks can be mitigated and care, e.g., access to healthcare as well as broader support (including financial incentives), provided relatively quickly. Where recommendations are from other SAGE-endorsed papers but supported by the Ethnicity Subgroup, this is indicated.

13. As detailed below, there is a need for increased understanding and compliance to mitigate household transmission, and more specific guidance can help provide practical pragmatic strategies for different households and situations. However, guidance on its own should not be viewed as a magic bullet and must be accompanied by wider strategies to assess public understanding and barriers to compliance.

Recommendations

Clearer and more specific guidance for different kinds of households needs to be developed, supported by tailored communications strategies

1) Clear, inclusive guidance on how people can reduce transmission within a household (SPI-B and EMG, 2020). This guidance should be developed so as to be culturally-specific, available in multiple languages and reflect the diversity of family types and household compositions. Consideration should also be given to including seasonal-specific details particularly advice on reducing risks indoors including ventilation, hygiene and social distancing. Guidance should be tailored:
    i. for all households during the pandemic;
    ii. for those who are contacts of cases and;
    iii. for those who have symptoms.

2) Given the higher exposure risk for **larger households**, more specific guidance needs to be developed for these, for example:
    i. Guidance on how to reduce transmission in **households with large/multigenerational families** (noting that transmission may occur from those 'cared for' to carers as well as from younger to older members of the household).
    ii. Guidance on how to reduce exposure for **people providing informal care and support to family members or others in the community**. These practices which have specific cultural contexts should be recognised and supported by clear bubbling policies on household mixing advice that enable large households to join to provide care for each other when the R number permits. In addition, this would enable the strain of this gendered care work to be born more evenly within and across households (SPI-B, 2020b).

3) Government should issue clear guidance to **housing providers** – including landlords in the private rented sector – and occupants on improving housing conditions including ventilation provision and use (SPI-B and EMG, 2020).

4) Non-stigmatising **public health communications** should raise awareness and give advice to ***all*** UK households on how to reduce household exposure, and how to make domestic and care work safer (SPI-B and EMG, 2020).

5) Local and central government should consider **communications strategies that advise those in unpaid caring roles, particularly women**, on how to keep themselves safe and advise men on how to support women to do this. This guidance does not yet exist and needs to be co-designed and sensitive to different minority ethnic gender and age specific roles (SPI-B and EMG, 2020).

6) Targeted co-designed public communications should reflect a wide range of different family and household types, including multigenerational households.

Support and building connections with health services

7) **Practical support[2] should be offered to allow safe isolation of individuals living in crowded or multigenerational households**. This should involve a combination of offering alternative

[2] SPI-B has advised that practical support for self-isolating or quarantining within the home, such as support with shopping, pre-packed food to minimise shared time in the kitchen, provision of cleaning supplies, liaising with external organisations

accommodation for unwell individuals and the provision of paid emergency workers who could go into such households if large numbers of family members become unwell at once (SPI-B, 2020c). Consideration should be given to ensuring that **current social bubbles policy reflects the needs of minority ethnic groups living in larger multigenerational households**; and also communicated in a meaningful way so that it is clear how it applies to their households (for example, the term 'bubbles' does not translate easily into non-English languages so alternative terms should be identified which will resonate).

8) Community or health champions should be empowered to build greater trust between minority ethnic groups and health services and increase awareness of guidance and support available (SPI-B, 2020d).

Supporting economic measures

As the SPI-B paper on self-isolation (SPI-B, 2020c) argues it is important to provide positive economic support to promote adherence to non-pharmaceutical interventions NPIs. Minority ethnic groups face greater economic constraints, exacerbated by the economic impacts of the pandemic and are more likely to live in housing in deprived communities. Alongside higher average household sizes, this means that they will benefit more from mitigations in terms of housing. Such mitigations strategies should include:

9) In local authority areas with the greatest housing deprivation, provide emergency grants for repair and maintenance of social and private rental housing. As noted by the SPI-B/EMG paper (SPI-B and EMG, 2020), improving ventilation provision and use is critical.

10) Reduce economic constraints which are implicated in multigenerational and large households by removing the benefit cap, particularly in high housing cost areas, and, for immigrant families with members without settled status rescinding the No Recourse to Public Funds rule.

11) Additional space (spare rooms) increase opportunities to mitigate risks of within-household transmission in multi-person households; but minority ethnic groups are less likely to have access to such space. Conversely, those in local authority housing and subject to the under-occupancy levy ('bedroom tax') on benefit income face greater challenges in reducing within-household transmission. The implementation of the bedroom tax should be reviewed for those in multi-person households.

12) In the medium term, we need greater investment in safe, affordable childcare and alternative community spaces for social connection, particularly for the elderly, outside the home to ease the care and disease transmission burdens on disadvantaged and minority ethnic group households.

for wider support and anonymised helplines to respond to any concerns. This is particularly important for minority ethnic communities. See SPI-B Evidence Review for MHCLG Housing Impacts Paper, September 2020, p. 11.

Context

Substantial ethnic inequalities in Covid-19 risk have been observed in the UK and internationally. Previous evidence considered by SAGE (SAGE ethnicity sub-group, 2020a) has noted that substantial differences in household composition (I.e. the number of people living in a household and their ages) and housing characteristics exist across ethnic groups and could potentially contribute to these observed inequalities. This paper considers this issue in detail.

Household transmission

Measures to prevent Covid-19 transmission in institutional settings at high risk such as hospitals and care homes have been identified but there has been less focus on control of household transmission. This is despite evidence that exposure within households contributes a substantial proportion and potentially even a majority of transmission (Shen et al., 2020), although its importance will vary by season among other factors. Such strategies would need to be informed by an understanding of factors that influence risk of Covid-19 transmission within households. Such factors include environmental issues such as the quality of housing and ventilation, degree of crowding and household composition (i.e. who lives in a household) (Howden-Chapman, 2004) including the ages of household members (age structure), presence of co-morbidities and household occupations including key worker roles, behaviours and educational participation of household members.

Ethnicity and household transmission

Several aspects of household composition and housing characteristics could be related to ethnic inequalities in Covid-19. Those who live in crowded, low quality housing and in a multigenerational composition will be at greater risk of exposure and transmission which could therefore potentially contribute to ethnic inequalities.

Household composition among minority ethnic groups: Many minority ethnic groups in the UK have greater proportions of multigenerational households compared with the White ethnic group (ONS, 2020a). Multigenerational households are those where an adult aged 65 years or older co-resides with at least another person who is more than 20 years younger, or with a child. This is important because in addition to older age being a risk factor for severe Covid-19 severity, older adults are thought to be more susceptible to household transmission (Jing et al., 2020). Additionally, multigenerational households are more likely to have at least one family member with another disease that puts them at greater risk of Covid-19 when compared to single generational households (Mikolai et al., 2020). Furthermore, multigenerational households are more likely to include individuals who find it difficult to avoid exposure (such as school-aged children and working-aged adults). Differences in household composition by ethnicity have also been reported in the US and Canada. For example, Black Americans are more likely to live in multigenerational households and only one in five Black Americans are in occupations that allowed them to work from home (Millett et al., 2020). Similarly, indigenous families in Canada, particularly First Nations people and Inuit, are more likely to live in multigenerational households and in unsuitable housing conditions (Statistics Canada, 2020).

Overcrowding: For people who live in the same household as someone who tests positive for Covid-19, current UK guidance is to isolate within the same home for 14 days. A recent survey suggested that while willingness to self-isolate was high across the whole population, the ability to self-isolate was lower in ethnic minority groups and those living in the lowest income households (Atchison et al., 2020). In addition, low-income households were less likely to be able to work from home. During the first UK-wide lockdown, workers were asked to work from home where possible and children were also at home due to school closures, suggesting members of larger households and/or overcrowded households were spending more time together indoors, enhancing the risks of household transmission.

Housing quality: Some minority ethnic groups are known to already have been living in poor quality housing before the pandemic (Garret, Piddington and Nicol, 2020). Where families were facing socioeconomic disadvantage and housing quality was already poor, this was exacerbated during lockdown due to difficulties in getting trades people into properties to carry out remedial work (Brown et al., 2020). Damp and mould were left untreated which have been associated with respiratory infections (Ingham et al., 2019), and this may be more problematic during a winter lockdown.

Synthesis of population studies

Five recent national studies have examined the relationship between Covid-19, ethnicity, and household composition using data from the REACT-2 study (Ward et al., 2020), UK Biobank, QResearch, OpenSAFELY (Mathur et al., 2020), and ONS Census data (Nafilyan et al., 2020). The studies used different types of data (household surveys, electronic health records and linked data based on the 2011 Census), and different populations, Covid-19 outcomes, definitions of household composition and statistical methods. Yet, despite these differences, the results from these studies are largely consistent and together provide compelling evidence for the independent effect of household composition on Covid-19 risk and outcomes. The methods of each study are summarized in Table 1 (appendix) and the results are summarized in Table 2 (appendix).

Study designs and Methods

The **REACT-2 study** conducted SARS-CoV-2 antibody tests on a random sample of 100,000 adults in England between June 20th June and July 13th, 2020. They calculated the odds of having SARS-CoV-2 antibodies by ethnic group and household size adjusting for age, sex, deprivation, region, employment status, ethnicity, and household size.

The **UK Biobank** is a cohort of adults who were aged 45-60 in 2006-2010 (and so who are currently 60+). The study included here examined the odds of testing positive for Covid-19 and suffering from severe Covid-19 (SARS-CoV-2 in hospital or Covid-19 death) by household size and ethnicity.

Both **QRESEARCH and OpenSAFELY** used the routine electronic health records of adults residing in England. **QRESEARCH** estimated risk of SARS-CoV-2 infection, hospital admission, intensive care admission, and Covid-19 mortality by both ethnic group and household size, adjusted for age, sex, deprivation, care home status, co-morbidities and medication use. **OpenSAFELY** estimated risk of SARS-CoV-2 infection and Covid-19 mortality by ethnic group with and without adjustment for household size in addition to adjustment for age, sex, deprivation, clinical risk factors and co-morbidities. People residing in care homes were excluded from the OpenSAFELY population.

The **ONS study** included all adults in England aged 65 or over in 2020 who were living in private households at the time of the 2011 Census and who had not moved to a care home by 2019 and were still alive on 2nd March 2020. The study firstly examined the risk of Covid-19 death according to whether or not people lived in a multigenerational household, and secondly estimated the causal contribution of living in a multigenerational household to ethnic differences in Covid-19 death using a causal mediation analysis.

Main Findings

- Compared to White ethnic groups, those from minority ethnic groups, particularly of south Asian origin, tend to live in larger or multigenerational households (households where someone aged 65 or older co-resides with another adult at least 20 years younger, or a child).
- All studies document that living in large or multigenerational households is associated with greater risk of Covid-19 infection, hospitalisation and death. The associations remain once socio-demographic factors and underlying health status are adjusted for.
- The QResearch, OpenSAFELY and ONS studies show that household composition explains an important proportion of the additional risk of acquiring SARS-CoV-2 infection and mortality in south Asian ethnic groups, but not other ethnic groups. There is also some indication from the ONS study that the household composition explains more of the elevated risk of Covid-19 death for south Asian women than for south Asian men or people from other ethnic groups..

Summary of findings from each study

- The **REACT-2 study** showed that after taking account of demographic characteristics (differences in age and sex), region, deprivation, and occupation, risk of infection was higher

in households of 5 or more people vs. single person households, and for people of Asian and Black ethnicity compared to White ethnic group net of household size.

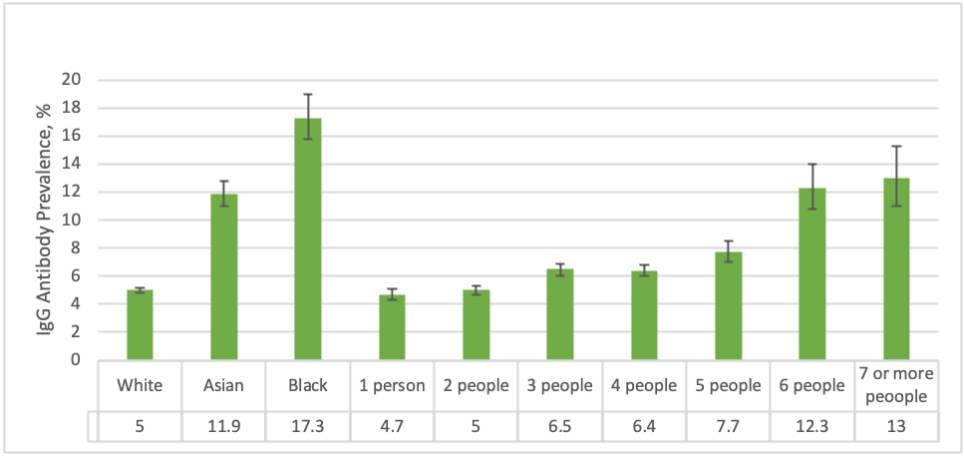
- In the **UK Biobank study**, living in a household of three or more people was associated with increased odds of testing positive for Covid-19 for the White ethnic group and the south Asian groups, and increased odds of severe Covid-19 for south Asian groups only.
- The **OpenSAFELY study** found that household size accounts for 10-16% of the additional risk of testing positive for SARS-CoV-2, and 12-39% of the additional risk of Covid-19 mortality in south Asian groups, after accounting for demographic characteristics (age, and sex), deprivation, region, and co-morbidities. Accounting for household size in addition to all other characteristics, accounted for all the differences in risk of Covid-19 mortality between White and Pakistani and almost all the difference between White and Bangladeshi groups.
- A study by the ONS found older people (aged 65 or more) living in multigenerational households were more likely to die from Covid-19 than those living only with other older adults after accounting for age, household overcrowding, geographical factors, socio-economic factors, and underlying health. The effects were more pronounced for women than men.
- This **ONS study** also found that living in a multigenerational household explained 10-15% of the additional risk of Covid-19 death amongst older women from South Asian backgrounds after accounting for age, household overcrowding, geographical factors, socio-economic factors, and underlying health, but very little for men or people from other ethnic groups.
- The **QResearch study** showed that, relative to people living in households with 2 people, people in households with 3-5 individuals had a 31% increased risk of a Covid-19 positive test; 33% increased risk of a Covid-19 hospital admission; 18% increased risk of a Covid-19 ICU admission and a 36% increased risk of Covid-19 associated death. The strongest increases associated with ethnicity were observed for Covid-19 ICU admissions where all minority ethnic groups had increased risks compared with the White ethnic group.

DETAILED FINDINGS FROM FIVE RESEARCH STUDIES

REACT2 study: SARS-CoV-2 infection

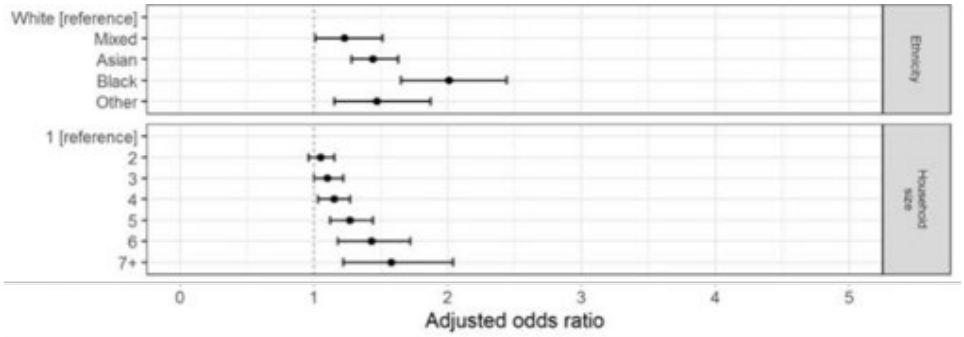
- REACT-2 is a cross-sectional study in which a random sample of 100,000 adults in England were tested for the presence of SARS-CoV-2 antibodies between 20th June and 13th July 2020. This allowed the study investigators to estimate the community prevalence of SARS-CoV-2 infection in England by age, sex, ethnic group, deprivation, region and household size.
- Antibody prevalence was 5% for White ethnic group, 11.9% for south Asian and 17.3% for Black minority ethnic group **(Figure 1)**.
- Antibody prevalence increased from 4.7% for individuals residing in single person households to 13% for individuals residing in households of 7 or more people **(Figure 1)**.
- After taking account of the effect of alternative factors such as demographic characteristics, region, deprivation, and occupation, the risk of infection was higher in households of five or more people than in single person households. It was also higher for people of Asian and Black ethnicity than the White ethnic group, even after adjusting for household size and other factors **(Figure 2)**.

Figure 1. Prevalence of SARS-Cov-2 IgG antibodies by ethnic group and household size in REACT-2 study



Note: Prevalence adjusted for test performance and weighted to population of England (18+ years)

Figure 2. Odds of SARS-CoV-2 infection by ethnic group and household size in REACT-2 study



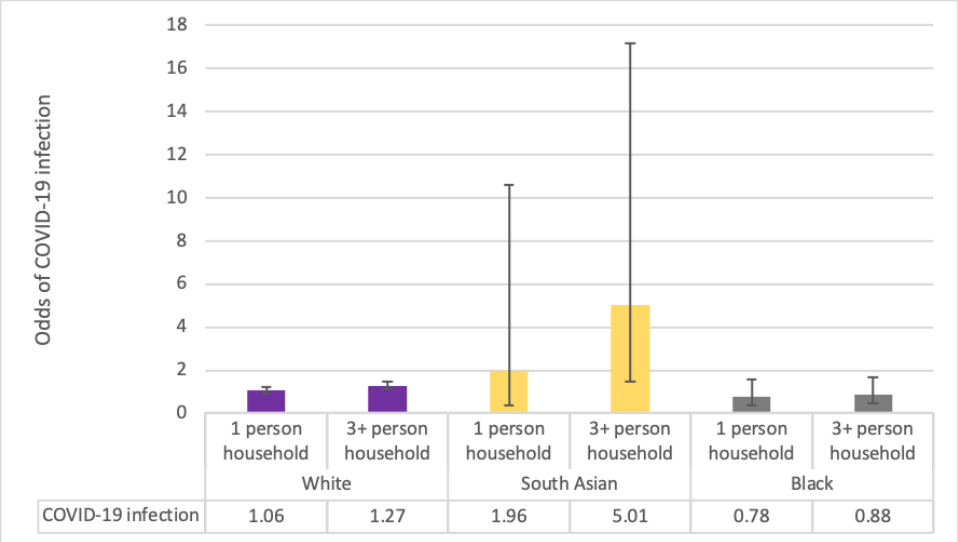
Note: Jointly adjusted odds ratios obtained from multivariable logistic regression adjusting for age, sex, ethnicity, region, deprivation, household size and employment status.

UK Biobank study

Household size and testing positive for SARS-CoV-2 infection

- After adjustment for age, sex, and deprivation, odds of having a positive Covid-19 test were raised for the White ethnic group and south Asian minority ethnic group living in households of three or more people compared to those living in households of two people.
- Household size was not associated with odds of testing positive for people of Black ethnicity **(Figure 3).**

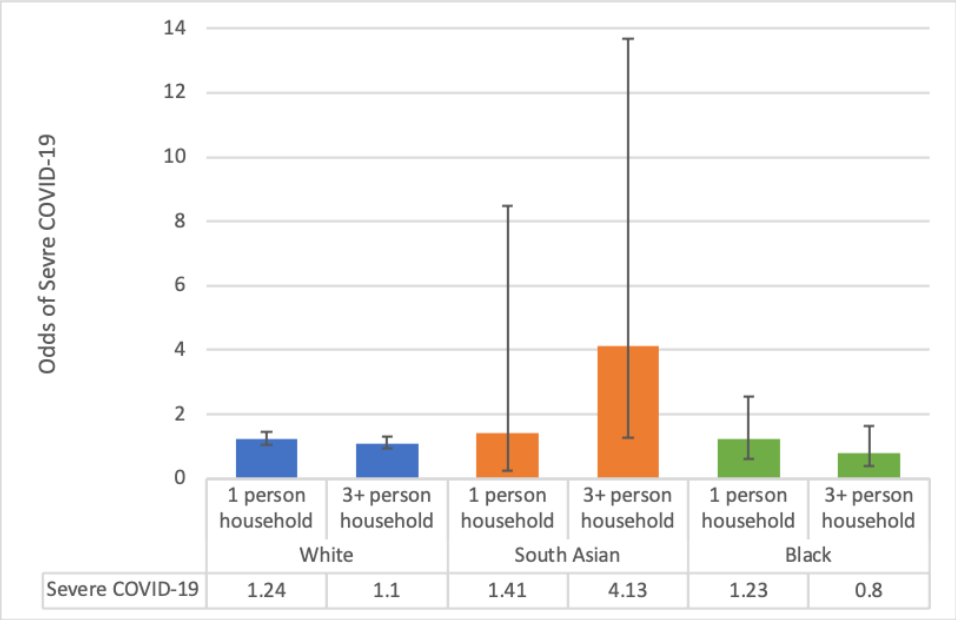
Figure 3: Odds of testing positive for SARS-CoV-2 infection by household size and ethnic group (2 person households is the reference category)



Household size and Severe Covid-19 (positive test in hospital or Covid-19 mortality)

- When compared to those living in 2 person households, the odds of severe Covid-19 were higher for south Asian people living in households of three or more after adjustment for age, sex, and deprivation.
- For Black and or White ethnic groups household size was not significantly associated with the odds of severe Covid-19 **(Figure 4).**

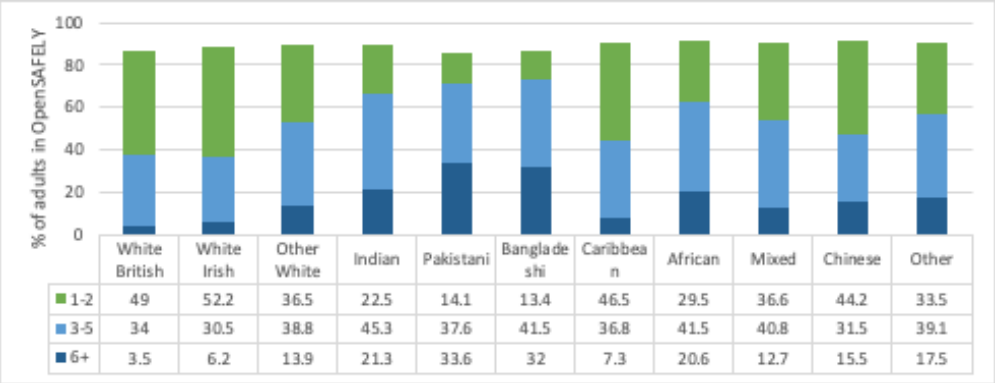
Figure 4: Odds of severe Covid-19 by household size and ethnic group (2 person households is the reference category)



OpenSAFELY study

- **Ethnic differences in Household size.** Household size varies substantially between ethnic groups for example, 3.5% of people from White British ethnicity lived in households of six or more people, compared to 21.3% for Indian, 33.6% for Pakistani, 32% for Bangladeshi, 7.3% for Caribbean and 20.6% for African ethnic groups **(Figure 5)**.

Figure 5. Percent of adults residing in households of 1-2 people, 3-5 people, and 6 or more people, by minority ethnic group in OpenSAFELY



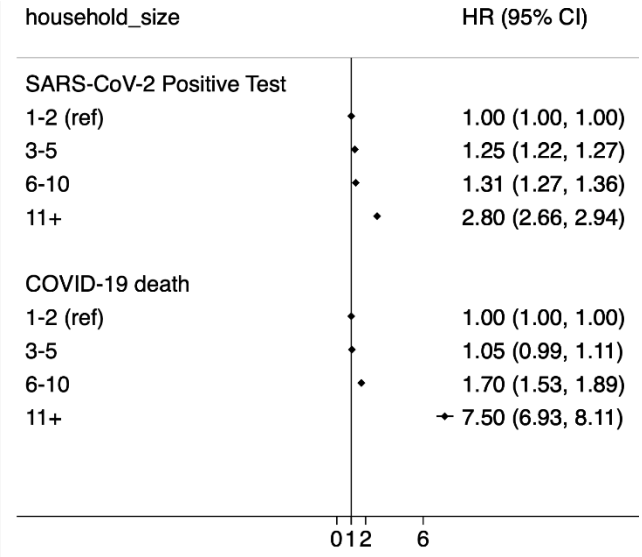
	White British	White Irish	Other White	Indian	Pakistani	Bangladeshi	Caribbean	African	Mixed	Chinese	Other
1-2	49	52.2	36.5	22.5	14.1	13.4	46.5	29.5	36.6	44.2	33.5
3-5	34	30.5	38.8	45.3	37.6	41.5	36.8	41.5	40.8	31.5	39.1
6+	3.5	6.2	13.9	21.3	33.6	32	7.3	20.6	12.7	15.5	17.5

*13% of individuals in OpenSAFELY had unknown household size, thus percentages do not add up to 100%

Household size, SARS-CoV-2 infection and Covid-19 mortality

- Compared to people living in households of 1-2 people, risk of SARS-CoV-2 infection was higher by 25% for people living in households of 3-5 people, 31% for those in household of 6-10 people and almost tripled for those living in household of 11 or more people, after accounting for ethnicity, demographic characteristics, deprivation, region, and clinical co-morbidities (Figure 6).
- Compared to people living in households of 1-2 people, risk of Covid-19 mortality was increased by 70% in those living in households of 6-10 people and increased by 7.5 times for those living in households of 11 or more people (Figure 6).
- This analysis excluded people living in care homes but may have included people living in houses of multiple occupation, schools and universities, or other large residential accommodation.

Figure 6. Risk of testing positive for SARS-CoV-2 and Covid-19 mortality by household size



Note: Hazard ratios derived from Cox regression adjusted for age, sex, ethnicity, deprivation, co-morbidities, clinical risk factors (BMI, glycated haemoglobin, blood pressure, smoking status), number of GP consultations and region.

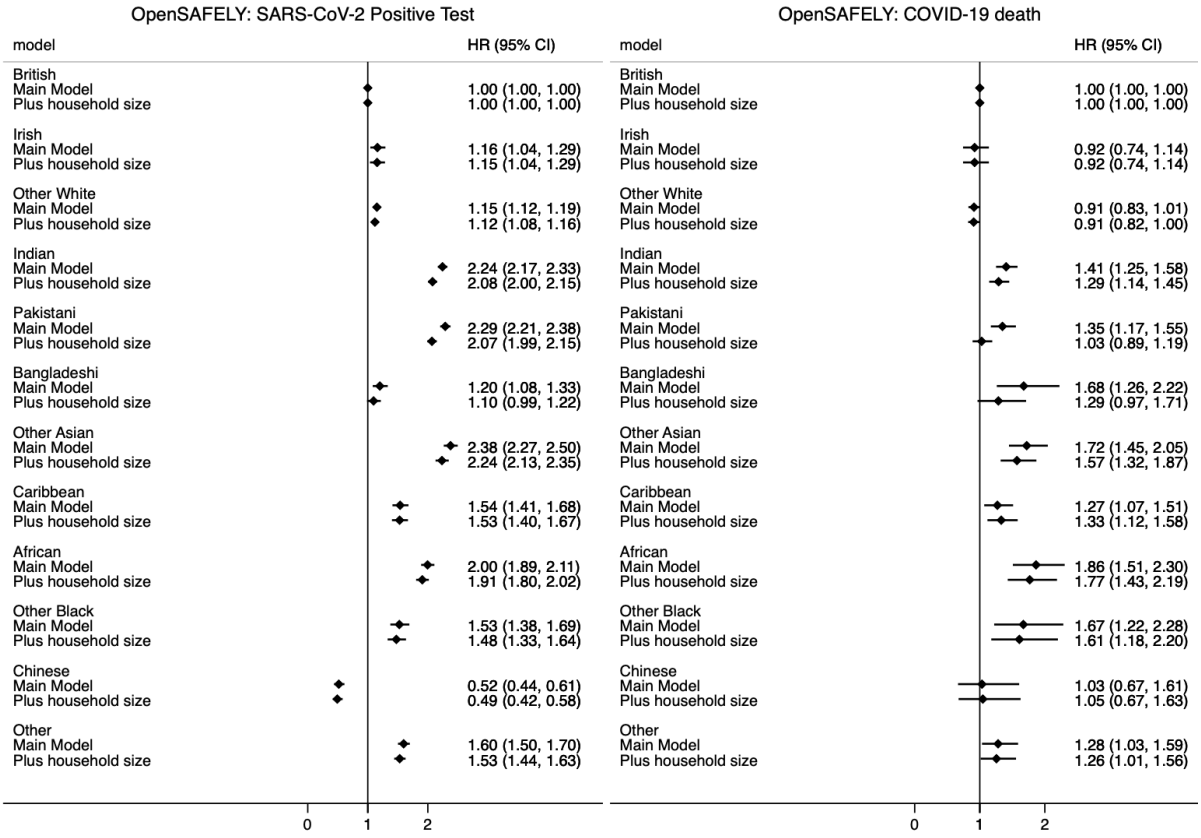
Relationship between Household size and ethnicity in testing positive for SARS-CoV-2 <u>infection</u>

- Household size explained some of the excess risk of **testing positive for SARS-CoV-2** even after accounting for demographic characteristics, deprivation, region, and clinical co-morbidities.
- When accounting for household size, the risk of **testing positive** was reduced by 16% in Indian people, 22% in Pakistani groups and 10% in Bangladeshi groups compared to White British groups, after accounting for demographic characteristics, deprivation, region, and clinical co-morbidities.
- For Black ethnic groups, accounting for household size reduced the risk of testing positive by 9% in African groups and 5% in Caribbean groups compared to the White British ethnic groups after accounting for all other risk factors **(Figure 7).**

Relationship between Household size and ethnicity in Covid-19 <u>mortality</u>

- Household size is likely to explain for some of the excess risks of Covid-19 mortality across ethnic groups.
- Adjusting for household size reduced the risk of **Covid-19 mortality** by 12% in Indian ethnic groups, 32% in Pakistani and 39% in Bangladeshi groups in comparison to the White British ethnic groups after accounting for demographic characteristics, deprivation, region, and clinical co-morbidities.
- Accounting for household size in addition to all other characteristics, means that no differences in risk of Covid-19 mortality remain between White and Pakistani and little-to-no difference between White and Bangladeshi groups.
- Adjusting for household size reduced the risk of Covid-19 mortality by 9% in African people in comparison to White British after accounting for demographic characteristics, deprivation, region, and clinical co-morbidities. **(Figure 7)**.

Figure 7. Ethnic differences in risk of testing positive for SARS-CoV-2 and Covid-19 mortality with and without adjustment for household size in OpenSAFELY (White British ethnic groups is the reference)



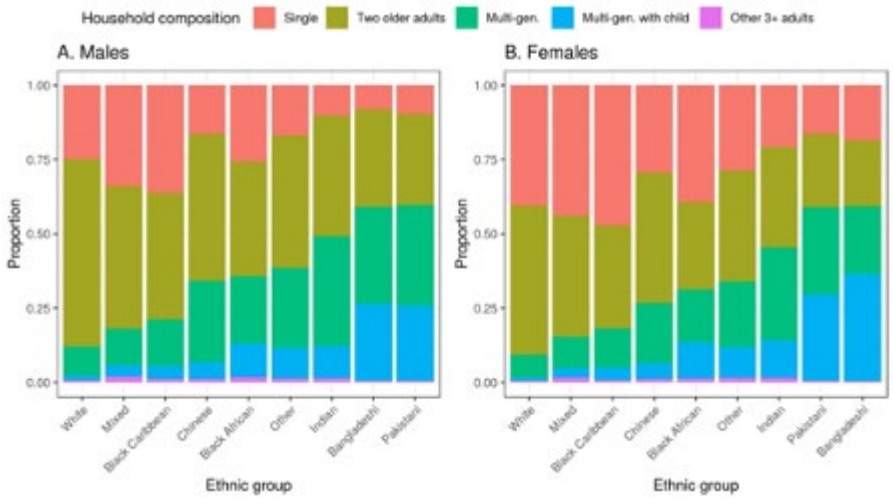
Note: Fully adjusted hazard ratios derived from Cox regression adjusted for age, sex, deprivation, co-morbidities, clinical risk factors (BMI, glycated haemoglobin, blood pressure smoking status), number of GP consultations and region.

ONS study

Multigenerational households and ethnicity

- Just under 10% of men and women aged 65 and older from a White ethnic group live in a multigenerational household.
- The same was true for 58.4% of Bangladeshi men and 60.0% of Bangladeshi women, 59.1% and 58.4% of Pakistani men and women and 47.9% and 45.8% and 43.9% of Indian men and women aged 65 and older **(Figure 8)**.

Figure 8. Household composition by ethnic group for people aged 65 and over (ONS)

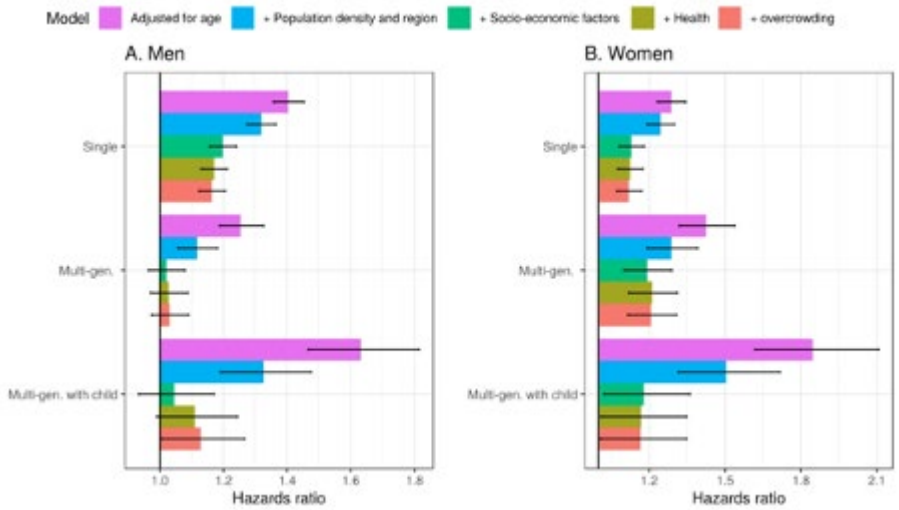


Note: Data linked between ONS Census and mortality registration data, England, and Wales. People aged 65+, excluding those living in care homes in 2019. The number of adults in the household is calculated as the number of people aged 16 or over who lived in the household at time of the Census, minus those who died between 2011 and 1st March 2020. Multigenerational household is defined as a household where someone aged 65 or over in 2020 co-resides with at least another adult who is over 20 years younger, or with at least one child.

Multigenerational households and Covid-19 mortality

- There is a strong relationship between living in a multigenerational household and the risk of Covid-19 death, especially for women.
- Both older men and women living a multigenerational household were more likely to die from Covid-19 than older people living with another older adult, once we adjust for age.
- For men, after adjusting for individual and household characteristics, living in a multigenerational household without children is not associated with a higher risk of Covid-19 mortality.
- Living in a multigenerational household with children is associated with a 1.13 [95% confidence interval (CI): 1.01-1.27] times greater risk of Covid-19 related death. Compared to living with another older adult, the rate of Covid-19-related death was 1.22 [1.13 - 1.32] and 1.17 [1.01 - 1.35] greater for women 65 or over living in a multigenerational household without and with children respectively **(Figure 9).**

Figure 9. Hazard ratios for Covid-19 related death compared to two older adult households, stratified by gender

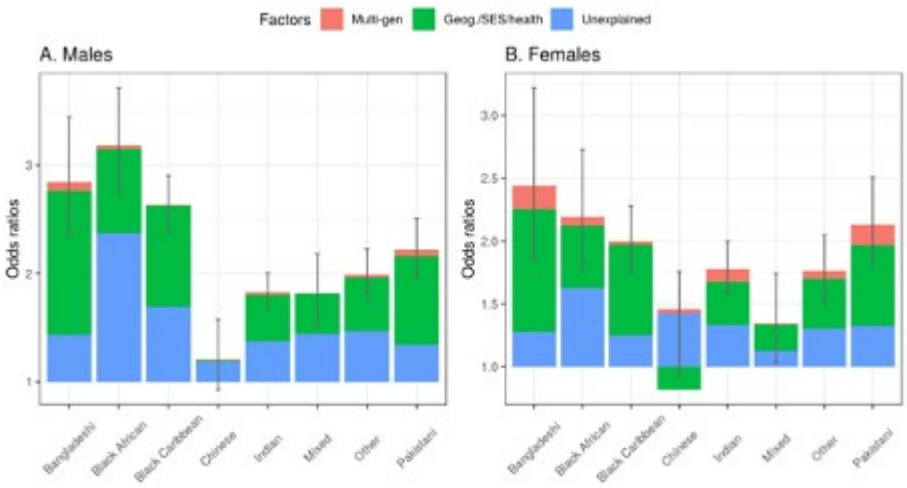


Note: Hazard ratios compared to living in a two older adults household obtained from Cox proportional hazard models. Death involving Covid-19 between 2 March 20202 and 27 July 2020. Geographical factors: region, population density, urban/rural classification; socio-economic characteristics: ethnicity, IMD decile, household deprivation, educational attainment, social grade, household tenancy; health: self-reported health and disability from the Census, pre-existing conditions based on hospital contacts, number of hospital admissions, total days spent in hospital; overcrowding: living in an overcrowded household, property type.

The proportion of ethnic differences in Covid-19 mortality explained by living in a multigenerational household

- Using a causal mediation analysis, we find that living in a multigenerational household explained a substantial part of the difference in risk of Covid-19 mortality for older women from South Asian groups, but not for older men or those from other ethnic groups.
- For older women from a Pakistani background, living in a multigenerational household accounted for 14.4% of the difference in Covid-19 mortality compared to White ethnic group. For women from Bangladeshi and Indian backgrounds, it explained for 12.9% and 13.0% of the difference in mortality respectively **(Figure 10)**.
- Living in a multigenerational household explained only a small proportion of the excess Covid-19 mortality for men and women from other ethnic groups.

Figure 10. Explaining the difference in Covid-19 mortality by ethnic groups: the role of living in a multigenerational household (ONS)



Note: The overall height of the bar corresponds to the age-adjusted Odds ratios (ORs) based on a logistic regression model. 95% confidence intervals. The proportion of the age-adjusted ORs explained by living in a multigenerational household were calculated through a causal mediation analysis. The unexplained part corresponds to the Odds ratios from a model adjusted for age, geographical factors (region, population density, urban/rural classification), socio-economic characteristics (IMD decile, household deprivation, educational attainment, social grade, household tenancy), health: (self-reported health and disability from the Census, pre-existing conditions based on hospital contacts, number of hospital admissions, total days spent in hospital)

QResearch study

Sample

Primary care database covering population of 9.7 million adults, followed from 24th Jan 2020 to 31st Aug 2020 linked to (a) SGSS Covid test results (b) Hospital Episode Statistics admitted patients (c) Hospital Episode Statistics critical care (d) civil registration data.

Outcomes

1. Covid-19 positive test
2. Covid-19 related hospital admission (NHS England definition)
3. Covid-19 related critical care admission
4. Covid-19 related death - either Covid-19 recorded on death certificate or death from any cause within 28 days of a positive test results.

Household size

Based on groupings of patients in primary care records using the household key which is a unique identifier based on the patient's address. Household size was categorised as 1, 2, 3-5, 6-9, 10 or more (including adults and children of all ages)

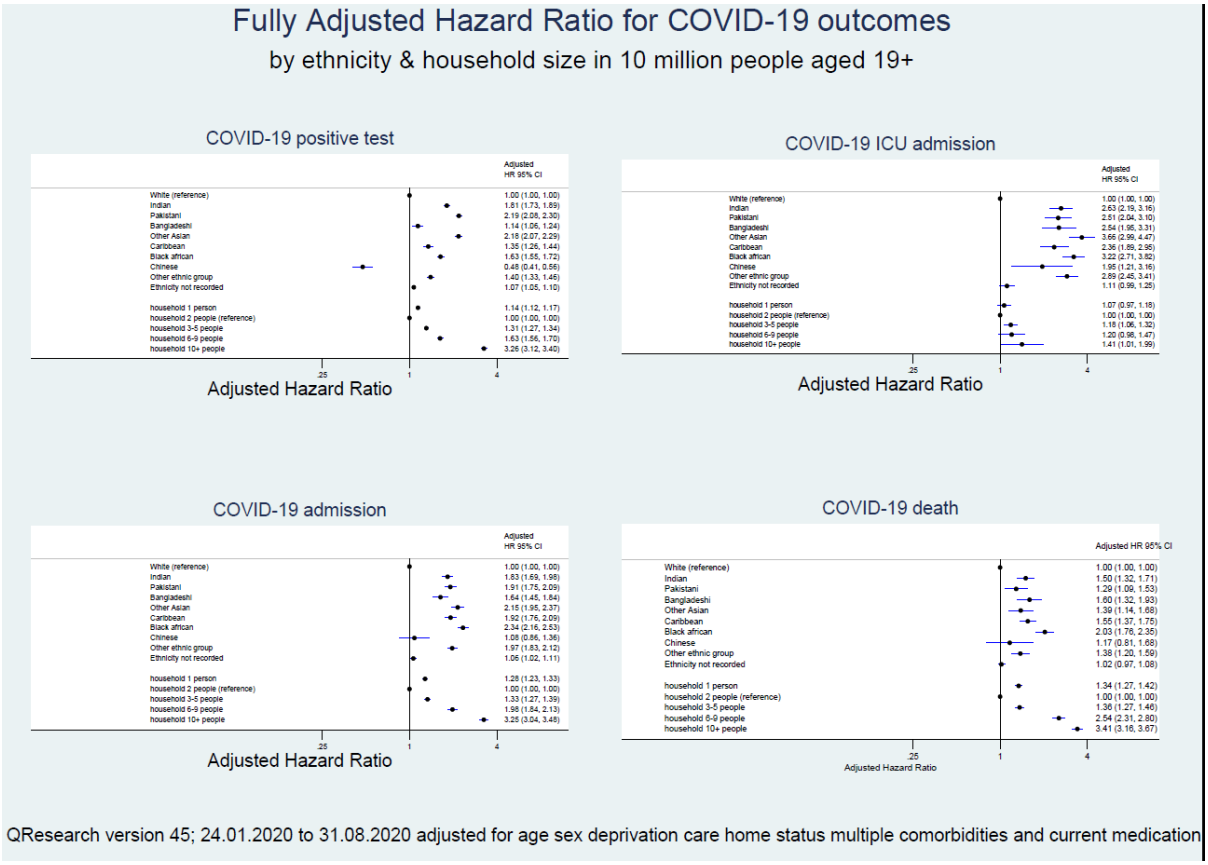
Results

The Table shows the proportion of people in each ethnic group by household size - for example, 36.7% of White ethnic groups are in a household of 1 person, 28.2% in a household of 2 people, 31.2% in one of 3-5, 2.62 in one of 6-9 people and 1.3% in a household of 10 or more. For Bangladeshi, the corresponding figures are 22.4%, 13.3%, 42.5%, 19.5% and 2.4%.

household size	1 person	2 people	3-5 people	6-9 people	10 or more	Total
	row %					
White	36.74	28.23	31.17	2.62	1.25	100
Indian	27.6	19.49	44	7.3	1.61	100
Pakistani	25.27	14.38	40.95	17.13	2.27	100
Bangladeshi	22.37	13.27	42.48	19.49	2.39	100
Other Asian	30.9	18.48	40.1	8.37	2.15	100
Caribbean	45.96	21.82	27.97	3.49	0.76	100
Black African	38.85	17.14	33.78	8.73	1.5	100
Chinese	44.47	17.55	26.79	5	6.2	100
Other ethnic group	38.43	20.43	33.35	6.08	1.71	100
Ethnicity not recorded	34.64	24.75	35.58	3.7	1.34	100
Total	35.85	25.93	32.96	3.87	1.39	100

Household size and ethnicity independently associated with increased risk of all four outcomes as shown in the Figure below.

- relative to people living in households with 2 people, people in households with 3-5 individuals had a 31% increased risk of a Covid-19 positive test; 33% increased risk of a Covid-19 hospital admission; 18% increased risk of a Covid-19 ICU admission and a 36% increased risk of Covid-19 associated death.
- people in households with 6-9 people had a 63% higher risk of a positive test; 98% increased risk of hospital admission; 20% increased risk of ICU admission and 2.54-fold increased risk of death.
- For people living in households of 10 or people more the corresponding values were 3.26-fold increased risk for a positive test; 3.25-fold increased risk for hospital admission; 1.41-fold increased risk for ICU admission; 3.4-fold increased risk for death
- The strongest increases associated with ethnicity were observed for Covid-19 ICU admissions where all minority ethnic groups had increased risks compared with the White ethnic group.
  Household size does not fully explain the increased risk of adverse outcomes associated with minority ethnic groups.



Note: Fully adjusted hazard ratios for outcomes of positive tests ICU admission, admission and mortality as a result of Covid-19. From the QResearch study.

DISCUSSION

What are the drivers of Covid-19 transmission in households?

The EMG/SPI-B housing report identified that rates of transmission in housing are high but concluded that existing datasets were not sufficient to determine causal relationships and transmission pathways. Overall, it argued that household effects were due to a complex interaction of internal and external drivers including occupation, housing quality and crowding, age composition and social relationships. Evidence from the studies detailed above suggest firstly, that living in multiple occupant or multigenerational households (household composition) is associated with risk of with SARS-CoV-2 infection and Covid-19 disease. One of the studies (ONS) found evidence of a causal relationship between household composition and Covid-19 mortality for adults over 65 years of age, though this is yet to be replicated in other datasets and age-groups.

The new quantitative studies covered in this report have, however, identified that household composition is associated with greater Covid-19 risks but despite differences in prevalence of multigenerational or larger households among minority ethnic groups, the results show that this driver explains only a limited proportion of ethnic differences in Covid-19 risks. Studies from OpenSAFELY and ONS examined the relationship between ethnicity and household composition. Both suggested some evidence of the effect of household composition varying by ethnic groups. These new studies also provide some evidence of a relationship between household size and age composition and the risks of transmission and mortality from Covid-19, in line with the probable risk factors for transmission within the home that were reported in the EMG/SPI-B housing report. Such likely household-related risk factors for Covid-19 include:

a. high level of risk due to numbers of occupants, shared spaces and facilities, poor ventilation and length of exposure;
b. high risk of exposure of household members outside the home due to a high level of occupational, family and social connectivity;
c. high level of risk within the home due to vulnerable household members, caring and domestic responsibilities, intimate social relationships (families) or barriers to communication and shared action (in houses of multiple occupation);
d. contribution of social deprivation to risk of occupational exposure, poor health and inadequate housing, and barriers to implementing mitigations, including overcrowding and lack of resources and control over housing conditions.

The studies in this report provide evidence that exposure within the household between household members is associated with Covid-19 risk (risk factor a). In particular, it is noteworthy that the effect of household composition is evidenced in most studies even after adjusting for deprivation and health conditions, suggesting that it is not simply the association of more dense living conditions with poor health and deprivation (risk factor d) that is driving the effects. The findings also are consistent with the co-residence of vulnerable household members and those with caring responsibilities (risk factor c), though they do not provide direct evidence of this connection. They also speak less directly to (risk factor b) though this remains a potential source of transmission that merits further attention; nor do they provide evidence on the role of barriers in HMOs, cited in (risk factor c), since these extra-household factors and households of multiple occupation were not directly investigated in the new studies.

The findings from the studies summarised in this report highlight the fact that there are large differences in household composition across ethnic groups. The association of Covid-19 risks with household composition thus tends to explain some of the differences across ethnic groups in such risks. Nevertheless, there is variation in the explanatory contribution of household composition across studies, and differences in household composition are not the only drivers of ethnic differences in Covid-19 infection, severity and mortality risks, over and above the other factors adjusted for. Part of the reason for some of the differences in the extent to which measures of household composition offer explanatory power may stem from differences in study design, statistical power to identify effects and definitions. This is further complicated by the fact that there is strong overlap between measures of household size, household composition and measures of overcrowding *per se,* making it harder to identify the individual contribution of each factor. Mismeasurement of housing-related

variables is likely to lead to under-estimating their contribution to risks of infection or mortality overall and to ethnic inequalities in Covid-19 outcomes specifically, since proxies for household composition may have different meanings across groups. For example, household size may be more strongly associated with overcrowding for some groups than others, while measures of multigenerational households may capture different forms of co-residence and inter-personal interaction across ethnic groups. Existing research has shown that the relationship between housing tenure and health differs across ethnic groups (Darlington-Pollock and Norman, 2017).

In this discussion section, we therefore start by considering different ways of conceptualising and measuring household composition and their implications for mechanisms of transmission or severity of Covid-19. It is important to note that various forms of 'non-standard' housing that may have implications for Covid-19 transmission risks and which also differ across ethnic groups are not well-captured by the measures of size or multigenerational composition that have been used in the preceding analyses. These include households with members from multiple occupation, as well as institutional forms of housing (homes for looked after children; immigration centres, prisons, hostels for workers etc.). While it is beyond the scope of this paper to consider such housing contexts it is important to note their potential role in the contribution of housing context to Covid-19 infection. These household forms are also likely to differ in prevalence across ethnic groups.

Since household composition *does* account for some differences in risks across the population, as evidenced in all the five studies, it invites us to identify the likely mechanisms. Candidates here are primarily around exposure. The modelling of the extent to which housing 'explains' ethnic differences in risks implies, by construction, that these mechanisms are largely common across groups.

Household size is clearly an indicator of the number of people who are likely to have close contact on a repeated basis. The simple number of people in a household increases the chances of spreading infection, while repeated interactions within the household may contribute to viral load where an individual with an infection is present. The evidence from all five studies suggest that the number of the people in the household is associated with greater risks of contracting Covid-19 in general. Larger households can take many different forms: they may include multiple adults or only one or two adults with multiple children. **Given the strong age gradient associated with Covid-19 risks of severity and mortality, capturing the composition of households with members of different ages may therefore give greater analytical purchase on transmission of risks and mechanisms of transmission**. Multi-level modelling may be a statistical approach that is particularly helpful for investigating this. The ONS analysis reported above therefore uses a measure of multigenerational households where the risks are estimated for older (65+) adults who are or are not living with working age adults and/or children. This implies that it is the increased infection introduced by (exposure to) younger members of the household which is responsible for the significant associations that are observed. However, the circumstances of the younger (adult) members of the household also matter for the likelihood that they will transmit infection. For example, whether they are key workers, or in contexts where they are interacting with multiple others. This may be one reason why household composition does not account for more of the overall infection /mortality risks (net of other relevant factors): the measure does not capture the detailed pathways and therefore is associated with substantial 'noise'. It may also help to explain why the analyses do not account for more of the differences *between* groups, since the occupational distribution of ethnic groups differs substantially. Those from Black African minority ethnic group are more likely to work in key worker roles, particularly health and social care key worker roles (Platt and Warwick, 2020), and in occupations with higher mortality risks (Office for National Statistics, 2020b). Hence, the consequences of living in an intergenerational - or simply a larger – household may have different implications. There is recent evidence that patient-facing care workers and their household members face enhanced risks (Shah et al. 2020). Conversely, differences in opportunities to work from home for some groups can be expected to reduce the risks associated with multigenerational households.

The experience and behaviours of older adults is also relevant to the extent to which they will be more exposed. It was notable in the ONS analysis that the effects of household size appeared to suggest a trend greater for women, and that household composition explained more of the risk of COVID-19 mortality for South Asian women than for south Asian men and people of other ethnic groups.This may be associated with the different circumstances in which women live in intergenerational households, for example, they are more likely to reside

with other family members once widowed, and potentially more vulnerable. This may in part be because for minority ethnic groups household composition is more strongly correlated with other factors which are already adjusted in the analysis, an issue we return to below.

At the same time, the direction of transmission is not, as much of the preceding analysis implies, necessarily from younger to older. Recent analysis also indicates that viral load may be also enhanced for younger members of multigenerational households as a result of caring for older adults who are infected (Little et al. 2020). Just as care workers are exposed to greater risk through their caring, so family carers looking after older adults are also more likely to be exposed to higher viral loads. This domestic and kin care has intensified during the Covid-19 pandemic in the UK due to a reduction in formal services and greater reliance on informal patterns of care (Bear et al., 2020). This evidence might also help to shed light on the apparent gendered differences of household composition effects in some of the analyses, since within-family care is more likely to be undertaken by women.

Household composition is clearly a relevant additional factor contributing to risks. It may, however, be offering less explanation than we might intuitively expect given the relevance of person-to-person contact for transmission of Covid-19, because housing conditions are already implicated in many of the measures that are already adjusted for in the analyses. That is, poorer housing conditions are linked to poverty and deprivation, and greater co-residence stems from the need to pool risks as well as from preferences. Poorer health outcomes both lead to as well as stem from poorer housing conditions and/or greater co-residence making it potentially less straightforward conceptually as well as empirically to isolate the independent effect of housing (Darlington-Pollock and Norman, 2017). At the same time, the fact that household composition only explains a part of differences in mortality does invite further attention to the other drivers that have been outlined as relevant, and which are not adjusted for in the preceding analyses, in particular the role of occupation, and related consideration such as transport use, and social support and kinship networks. These may also interact with housing conditions to enhance intra-household risks in certain cases.

The fact that household composition as measured in these analyses may account for some differences, though not consistently across all ethnic groups, might suggest that variations in household composition across ethnic groups are relatively unimportant in driving ethnic differentials in Covid-19 mortality or infection. However, there is also the possibility that housing effects differ by ethnic group. This would be picked up by an additive interaction (effect modification) in the quantitative analysis. Evidence for such differences in effects is suggested by the Biobank analysis which stratifies by ethnic group and reveals larger effects of household size for South Asian groups. Such effect modification would imply that housing effects differ across groups and lead to consideration of the specificity of the housing experiences of different ethnic groups – which qualitative research as well as other existing (pre-Covid-19) studies are able to shed light on.

Mitigation strategies to address household Covid-19 exposure and transmission

WHO advises that when someone does become infected with Covid-19 in a household, they should stay in a separate room from other family members, but if this is not possible, both the infected person and family members should wear a medical mask and keep at least 1 metre distance from each other. Where possible, the room should be well-ventilated (World Health Organization, 2020).

Countries across the globe have introduced housing-based control strategies to different extents. Wuhan, China had a strict stay at home policy coupled with a centralised isolation and quarantine policy where cases with mild to moderate Covid-19 were quarantined outside the home in large field hospitals. This allowed for less transmission within the household to other family members and could be better enforced (Chen et al., 2020). The centralised isolation, together with other strategies (e.g. travel restrictions, compulsory mask wearing in public places) reduced the R value from 3.54 at the beginning of the outbreak to 0.28 approximately a month later (Hao et al., 2020).

In Europe, most countries have asked people with mild to moderate illness to self-isolate at home. Where this is not possible to do safely, several countries (including Italy, Finland, Poland and Serbia and Lithuania) have adopted measures whereby hotels and hostels have been converted to accommodate self-isolating individuals

(HSRM, 2020). Preliminary evidence from the UK suggests the provision of accommodation such as hotels, to support self-isolation was viewed as acceptable, feasible and necessary (Denford et al., 2020).

To develop effective policies to mitigate transmission and related mortality from Covid-19 in households, we need to understand them not just as physical structures containing numbers or types of people. Communications and policies need to recognize that they are sites of social relationships informed by cultural values. In addition, they are part of a network of support structures of kin and care work, which carry risks of transmission, but which are also crucial to weathering economic and social shocks (Ochieng, 2011; Stack and Burton, 2016). In fact, Covid-19 and social restrictions to combat it have led to even more reliance on these values and networks to provide essential support and care (Bear et al., 2020). More people have formed multigenerational and multi-person households to cope with care burdens and economic hardship. The quantitative studies pick up on the transmission risks generated by these larger households and their kin and care work. But on the other hand, these ties are essential, now more than ever, and socio-culturally valued. Therefore, mitigating policies are unlikely to be effective or produce compliance unless they consider kinship values and the practical realities of social support and care work. This is especially true for disadvantaged and minority groups who rely more than others on these socio-cultural family and community ties (Adamson and Donovan, 2005). The gendered aspects of the household need to be taken into account too; especially as the 'risky' domestic work of caring for sick relatives, cleaning and laundry is predominantly carried out by women. **Therefore, we recommend that mitigation policies pay close attention to these issues of family values and cultures, social support, care work and gender especially in relation to interventions to help disadvantaged and minority groups.** The goal should be to make these networks safer, without undermining their significant social support role. This can be best achieved through a combination of socio-culturally sensitive, gendered communications along with practical economic interventions and enabling social bubble policies (when the R level is safe for this).

1. **Communications**

Targeted co-designed culturally tailored communications should be developed based on the kinship values of different kinds of families, including the extended families of minority ethnic groups. If people have to separate from extended networks or isolate themselves in households then this needs to be explained as an act of care in line with family duty. For example, rather than young adults just being told to save their grandmothers, we need messaging to grandmothers and middle-aged women that they need to save themselves from exposure rather than carrying out acts of self-sacrificing kin care. We may also want to particularly reach out to multigenerational households with specific age structures even before more quantitative evidence comes in. It is clear from the studies included here that multigenerational households that contain school age children create a riskier situation. However, recent research has also suggested that children do not increase the risks of severe Covid-19 outcomes (Forbes et al., 2020). It would be prudent to initially develop communications particularly for such household age structures.

In addition, public communications should be co-designed and targeted at those in unpaid caring roles, particularly women responsible for domestic and kin care. There has been almost no guidance on this even though paid domestic workers have been given clear rules to follow. They also need to be co-produced and sensitive to different minority and ethnic gendered and age specific roles so as to not alienate the population. Messages that are co-produced with the target community and tailored to reflect socio-cultural influences are more likely to reach the target community and include content that is more relevant which can increase knowledge, motivation and intention to comply with guidelines (SAGE ethnicity sub-group, 2020b).

2. **Practical Support**

We recommend practical support for isolation for family members in over-crowded or multigenerational houses. This would involve a combination of offering free alternative accommodation for unwell family members and the provision of paid emergency care workers who could go into such households if large numbers of family members become unwell at once. Paid care workers would ensure that multiple members of a household do not become sick from looking after each other and would be able to use PPE in the domestic setting. Such measures could feel 'unnatural' and against the values of kinship and care when they are used in relation to fellow family members. Practical support such as support with shopping, pre-packed food to minimise shared

time in the kitchen, provision of cleaning supplies, liaising with external organisations for wider support and anonymised helplines to respond to any concerns will ease the burden of domestic work for families that continue to care for family members. In addition, greater levels of financial payment for self-isolation should be made for disadvantaged and minority groups to allow them to follow the guidelines.

3. **Social Bubble Policies**

When the R level permits, more neutral and less discriminatory social bubble policies should be introduced to support the networks of domestic and kin care among disadvantaged and minority ethnic group households. These could be dialled up and down between the current one household and one lone individual connections, to also include a maximum of three households. These would support families to take care of each other in a time of economic and social stress as we recover from Covid-19. At present, we move between the extreme of permissive rule of six policies to highly restrictive lone individuals connecting with one other household or childcare bubbles. Neither of these measures fit the family structures of multigenerational or multi-person households. Government rules are more likely to be followed and accepted by people if they match their social networks better (SPI-B, 2020b). If family structures are supported by rules rather than disrupted by them, then communities are more likely to see the government and its Covid-19 policies as valid. For this reason, it would also be necessary to review the rule of six policy to ensure it meets the needs of different family structures and household types.

Synergistic policies

Beyond these mitigations founded in the values and practices of diverse households, we also recommend some other synergistic interventions that would further support households at risk:

1. **Synergies with Health Champion Policies**

While the previous measures will tackle issues of transmission, we also need to build public health environments and campaigns that build trust in institutions (SPI-B, 2020d). The healthcare sector may not be fully supporting women at risk in multigenerational households. There is often an assumption within health systems that South Asian women will assume traditional caregiver roles (Qureshi, 2013), which can lead to some women feeling neglected by health services and experiencing increased stress (Qureshi, 2013). During the pandemic, there was evidence of fears of stigma and of hospital environments in some South Asian groups (NHS Test and Trace, 2020) which could lead to delayed help-seeking behaviour and potentially explain differences in the severity of Covid-19 outcomes, reflected in the much larger role of household size for South Asians' Covid-19 risks compared to other groups in the Biobank study. To mitigate these risks, we recommend the use of **co-production, community participation, peer support and health champions as laid out in a recent SPI-B paper for SAGE** (SPI-B, 2020d). Health champions can work with communities and local authorities to co-create interventions (SPI-B, 2020d) that employ appropriate behaviour change techniques which can increase intentions to implement behaviour to reduce transmission in the home (Ainsworth et al., 2020; SPI-B, 2020d).

2. **Synergies with Interventions in Housing Policies**

It is highly likely that the high levels of transmission seen in the quantitative studies in this paper are connected to cramped, low quality and crowded housing as reported in the recent EMG/SPI-B paper on housing (SPI-B and EMG, 2020). All people, including minority ethnic groups, living in overcrowded and low-quality housing need immediate help (Charsley, Lambert and Smith, 1999; Marmot et al., 2020). In local authority areas with the greatest housing deprivation, we need emergency grants for repair and maintenance of social and private rental housing. Alongside this, we need clear government guidance to housing providers and occupants on improving ventilation provision and use. The spare room levy (the 'bedroom tax') has limited the amount of space available to families in social housing, space which can be crucial if, for example, members of the family return home (e.g. adult children returning, as happens in times of economic downturn), or there is a need for a carer to stay. The emphasis on within-household isolation during the pandemic is rendered much more of a challenge where there is no spare room. The bedroom tax should therefore be immediately revisited especially in deprived and over-

crowded areas to ensure this does not pose an impediment to self-isolation for households at higher risk of infection and transmission. Finally, the interaction of immigration and benefit systems, and 'no recourse to public funds' may exacerbate issues of overcrowding in cases where job loss arises and there is no potential to draw on state benefits (or social housing) – necessitating the use of informal arrangements. Therefore, we support the call to make exemptions to this rule faster and easier to receive. Concerted central government financial and regulatory measures to support local authorities improve the affordability and quality of social and private rental accommodation are essential as well.

Similarly, improved access to green infrastructure such as private or shared garden and parks could enable safe meeting of people outdoors and physical activity, reducing the risk of transmission as well as the negative unintended impacts of control measures on physical and mental health. However, the evidence for a relationship between disease transmission and poor-quality housing is well-established (World Health Organization, 2018). There is a need to pursue longer term programmes to reduce deprivation and to evaluate their implications for future health and housing related risks. Emerging evidence (discussed in this report) suggests such interventions would need to be tailored to ensure benefit for large Asian and Black minority ethnic group households as well as multigenerational households.

Immediate measures could be taken by providing funds to local authorities to support short-term emergency improvements to housing stock such as increasing ventilation and eliminating damp and mould (SPI-B and EMG, 2020). Since repair workers are allowed in homes during the current restrictions, this would be a feasible national strategy. In addition, as the national lockdown eases, the government and local authorities should make private open spaces such as school playing fields or golf club grounds available for families and friends to meet, especially in deprived and over-crowded areas. Lastly, there is a need to pursue longer term programmes to reduce deprivation and evaluate the impact of both short- and medium-term housing and built environment interventions on household transmission and exposure risk.

3. Synergies with Building Social Infrastructures

Over the longer term we need greater investment in the social infrastructures of safe affordable childcare and alternative community spaces for social connection, particularly for the elderly, outside the home to ease the care burdens on disadvantaged and minority ethnic group households. Especially as we recover from Covid-19 and its social and economic effects.

Conclusion and next steps

Overall, the studies suggest possible links between ethnicity, household composition and risks of Covid-19 transmission and mortality. However, they are not conclusive and further quantitative and qualitative research is required. In particular, there is a need for more causal mediation approaches: apart from the ONS analysis, analyses to date have assumed no intermediate confounding. There is also a need for examination of effect modification - i.e. do the effects of household composition differ across ethnic groups, and by gender? This will be particularly important to substantiate the role of the gendered pathways and practices discussed above. It is also important to investigate other types of household potentially at risk, in particular houses of multiple occupation and employer provided accommodation. The probabilities of living in such housing differ by ethnic group and are likely to render minority ethnic group men more vulnerable.

The studies do, however, confirm a significant link between household composition and exposure and death from Covid-19 showing how important policy for households is in the second wave and beyond. Additionally, the ONS study suggests a gender effect that makes women more vulnerable to exposure, and the Biobank study indicates that household size may matter more for Covid-19 impacts among South Asian groups. This report has shed light on the role of household composition in increasing risks of Covid-19 infection and mortality. It will be important to understand the role of specific occupational configurations as well as age configurations within the household to better capture the mechanisms of household transmission and how they might differ by ethnic group. In addition, it may be important to see the household more in the context of the wider community to understand increased transmission risks across differently sized or organised households.

Based on current evidence, short- and longer-term policy action is required to help all households. But given the greater prevalence of households with multiple risk factors among certain ethnic minority groups, interventions to address household level mechanisms would particularly benefit these groups. Policy approaches to support effective and non-stigmatising policies for UK households, which include advice to all UK households on how to keep domestic and care work safe, are required. This includes practical support for family members in over-crowded and/or multigenerational homes and when the national lockdown is lifted, social bubbling policies that better reflect extended family networks, particularly common among ethnic minority groups.

Funding to improve the quality of housing, more comprehensive access to state benefits, clear government guidance to housing providers and occupants on improving ventilation provision and housing policies that do not limit the amount of space available to families are required to reduce reliance on informal arrangements and reduce overcrowding in housing.

Over the longer term, greater investment in the social infrastructures of safe affordable childcare and community spaces for social connection, particularly for the elderly, outside the home, and financial and regulatory measures to improve the affordability and quality of social and private rental accommodation is required.

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Appendix

Table 1. Summary of the methods of included studies

Study	Aim	Outcomes	Population	Household measure	Statistical Methods
REACT-2	To estimate community prevalence of SARS-CoV-2 infection (antibodies) in England	SARS-CoV-2 infection (antibodies)	Random population based sample of 100,000 adults in England. 20 June to 13 July,2020 .	**Household Size:** Defined as continuous value between 1-6, and 7 or more people	Logistic regression comparing odds of SARS-CoV-2 infection between ethnic groups and households adjusted for age, sex and region, deprivation, occupation household size (for ethnicity comparisons) and ethnicity (for household size comparisons)
UK Biobank	To compare odds of testing positive for COVID-19 and suffering from severe COVID-19 by household size and ethnicity.	SARS-CoV-2 infection (positive test result) Severe COVID-19 (SARS-CoV-2 positive test result in hospital or COVID-19 death)	416,771 adults aged 40-69 at recruitment (2006-2010).	**Household Size:** categorized as 1 person, 2 people, and three or more people	Logistic regression comparing odds of COVID-19 outcomes across categories of household size with two person households as the reference category, adjusted for age, sex, and deprivation. Models were stratified by ethnicity.
OpenSAFELY	To estimate ethnic differences in COVID-19 infection and outcomes	SARS-CoV-2 infection (positive test result) COVID-19 mortality	17 million adults in England between March 1st and August 3rd, 2020	**Household Size:** categorized as 1-2 people; 3-5 people; 6-10 people; 11 or more people based on number of people registered at a practice using TPP software with the same home address.	Cox-regression comparing risk of COVID-19 outcomes by ethnicity, adjusted for age, sex, deprivation, co-morbidities, clinical characteristics, region, and household size.
ONS	1) To examine the relationship between living in a multigenerational household and COVID-19 death 2) To examine the contribution of living in a multigenerational household to ethnic differences in COVID-19 death.	COVID-19 mortality up to 27th July 2020	All adults in England aged 65 or over in 2020 living in private households at the time of the 2011 Census who had not moved to a care home by 2019 and were still alive on 2 March 2020.	**Household composition** in 2020 is derived based on the number of adults aged 25 or over and children aged 0 to 9 in the household at the time of the Census, exclude those who died before 1st March 2020 or moved to a care home **Multigenerational households** defined as households where someone aged 65 or over in 2020 co-resides with at least another	1) Cox regression comparing risk of COVID-19 mortality by multigenerational household status, adjusted for region, deprivation, and health status. 2) Causal mediation analysis comparing risk of COVID-19 between ethnic groups and quantifying the contribution of living in a multigenerational household All analyses are stratified by sex

				adult who is over 20 years younger or with at least one child.	
QResearch	To determine whether household size if an independent risk factor for COVID outcomes	(a) COVID-19 positive tes (b) COVID-19 admissino (c) COVID-19 ICU admission (d) COVID-19 death	9.7 million adults 19+ registered with 1305 GP practices in England alive on 24th Jan 2020	**House hold size based on EMIS household key. The household key is an anonymised identifier which represents a single address for an individual without disclosing what that address is**	Cox regression fully adjusted for age, sex, obesity, care home status, deprivation, multiple co-morbidities and concurrent medication

Table 2 Summary of the results of included studies

Study	Descriptive results	Analytic results	Considerations for interpretation
REACT-2	Antibody prevalence increased from 4.7% for people in single person households to 13% for people in households of 7 or more. Antibody prevalence was 5% for White, 11.9% for south Asian and 17.3% for Black respondents.	After adjustment, odds of infection were significantly raised in households of 5 or more people vs. single person households. After adjustment, odds of infection were significantly raised for people of Asian or Black ethnicity compared to White.	This study did not look at the odds of infection stratified by both ethnicity and household size.
UK Biobank	South Asian people made up 1.8% of the study cohort, 3.9% of those with a positive test and 4.2% of those with severe COVID-19 Black people made up 1.9% of the study cohort, 5.4% of those with a positive test and 5% of those with severe COVID-19 People living in households of three or more people made up 35.4% of the study population, 39.9% of those with a positive test,	After adjustment for age, sex, and deprivation, odds of having a positive COVID-19 test were raised for White and south Asian people living in households of three or more people compared to those living in households of two people. Household size was not associated with odds of testing positive for people of Black ethnicity. After adjustment for age, sex, and deprivation, odds of severe COVID were raised for south Asian people living in households of three or more compared to those living in households of two people/ Household size was not associated with odds of severe COVID-19 for people of White or Black ethnicity.	All people in this study are over the age of 50 in 2020, (mean age 67, SD 8). The category of households with three or more people is very heterogenous and may include small families, large/multigenerational families, houses of multiple occupation etc. Important not to over-interpret results due to small sample size (explaining the need to group houses of 3 or more together). The confidence intervals for south Asian and White groups marginally overlap – therefore cannot say with certainty that the association between household size and COVID-19 outcomes differs by ethnic group. Further evaluation of ethnic differences, may clarify whether these differences are clinically important.

	and 32.4% of those with severe COVID-19		
OpenSAFELY	5% of people of White ethnicity live in households of 6 or more people compared to 25% south Asian (21% Indian, 34% Pakistani, 32% Bangladeshi) and 17% Black (7% African, 21% Caribbean).	After adjustment for socio-demographic and clinical factors, additional adjustment for household size accounted for 10-16% of the excess risk of testing positive for SARS-CoV-2 and 12-39% of the excess risk of COVID-19 mortality in south Asian groups. Household size accounted for little or no excess risk in other ethnic groups after adjustment for all other characteristics.	The population included all adults age 18-105. Household size was based on the number of in the TPP software database registered at the same address (including children). We were unable to account for people living at the same address who may be registered at a GP practice using non-TPP software (so the household size for people residing in 'mixed software households' may have been underestimated. We are unable to distinguish family homes from HMOs – which may be included in household size categories of 6-10 and 11+ People residing in care homes were excluded from the OpenSAFELY population.
ONS	10% of adults 65+ of White ethnicity live in a multigenerational household, compared to 59% Bangladeshi and Pakistani and 46% of Indian adults aged 65+.	Living in a multigenerational household is associated with an increased risk of COVID-19 death, especially for women, after adjusting for a range of individual and household factors. Living in a multigenerational household explained 10-15% of the elevated risk of COVID-19 death amongst older women from South Asian background, but very little for men or people from other ethnic groups.	Population is older adults only (65+) Household composition is defined based the 2011 Census, only updated for deaths and move to care homes. Whilst household composition for people aged 65 and older may be more stable over time than for younger people, it is likely to be mis-measured. This measurement error is likely to attenuate the explanatory power of household composition in our models, therefore underestimating the effect of living in a multigenerational household
QResearch		relative to people living in households with 2 people, then people in households with 3-5 individuals had a 31% increased risk of a COVID-19 positive test; 33% increased risk of a COVID-19 hospital admission; 18% increased risk of a COVID-19 ICU admission and a 36% increased risk of COVID-19 associated death. The strongest increases associated with ethnicity were observed for COVID-19 ICU admissions where all minority ethnic groups had increased risks compared with the White group. Household size does not fully explain the increased risk of adverse outcomes associated with minority ethnic groups.	The population included in the study is all adults age 18-100. The household composition is based on the 'address ID' in the GP record which gives a unique household based on the GP registration. It includes all registered patients at that address (including children) but assumes there are no additional people in the household who are not registered with the same GP practice.